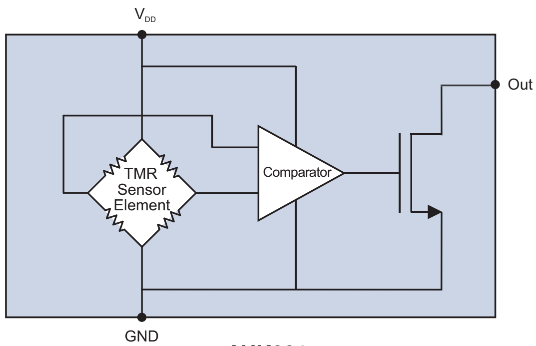
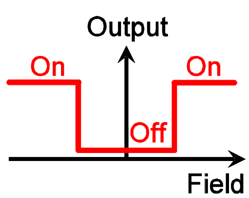
AHK991 High-Field, Low-Power TMR Switch

Functional Diagram



AHK991

Idealized Magnetic Response



Features

- Detection of large magnetic fields
- 350 mT operate point
- Unlimited maximm field
- 0.9 V – 1.8 V operating voltage for single-cell operation
- 2 µA typical quiescent current
- Continuous operation for low noise and high-speed
- Ultraminiature 1.1 x 1.1 mm package
- Omni-directional field sensitivity

Applications

- Single-cell battery or harvested power applications
- Tamper detection
- Limit switches
- Implantable medical devices
- MRI field detection

Description

The AHK991 is a digital switch for detecting large magnetic fields. They can withstand unlimited fields without being damaged or turning off.

The part uses novel tunneling magnetoresistance (TMR) technology to provide both the lowest quiescent current available in a continuous-duty solid state magnetic switch and large field detection. The sensor also provides unmatched miniaturization. The parts are available in NVE's ultraminiature 1.1 mm x 1.1 mm ULLGA leadless package or as bare die.

The output is configured as a magnetic "switch" where the output turns on when the magnetic field is applied, and turns off when the field is removed. The applied field can be of either magnetic polarity and in any direction, and the operate point is extremely stable over supply voltage and temperature. The output is current-sinking, and can sink up to 100 microamps.

The product consists of an approximately 0.6 mm x 0.6 mm die containing a TMR sensor element, CMOS signal processing circuitry to convert the analog sensor element output to a digital output.

Custom magnetic operating thresholds can be provided.

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Absolute Maximum Ratings

Parameter	Min.	Max.	Units
Supply voltage		5.5	Volts
Output voltage		5.5	Volts
Output current		200	µA
Storage temperature	−65	150	°C
Junction temperature		150	°C
ESD	500		V
Applied magnetic field		Unlimited	

Operating Specifications

<table>
<tr><td colspan="7">T_{min} to T_{max}; 0.9 V < V_{DD}<1.8 V unless otherwise stated.</td></tr>
<tr><th>Parameter</th><th>Symbol</th><th>Min.</th><th>Typ.</th><th>Max.</th><th>Units</th><th>Test Condition</th></tr>
<tr><td>Supply voltage</td><td>V_{DD}</td><td>0.9</td><td>1.5</td><td>1.8</td><td>Volts</td><td></td></tr>
<tr><td>Operating temperature</td><td>T_{MIN}; T_{MAX}</td><td>−40</td><td></td><td>85</td><td>°C</td><td></td></tr>
<tr><td rowspan="2">Magnetic operate point</td><td rowspan="2">H_{OP}</td><td>250</td><td>350</td><td>400</td><td rowspan="2">mT</td><td>25 °C</td></tr>
<tr><td>220</td><td>350</td><td>440</td><td rowspan="5">−40 °C to 85 °C
Fields in-plane</td></tr>
<tr><td>Operate point temperature coefficient</td><td>$\Delta H_{OP} / \Delta T$</td><td></td><td>0.07</td><td></td><td>%/°C</td></tr>
<tr><td>Operate point angle coefficient</td><td>$\Delta H_{OP} / \Delta\angle$</td><td></td><td>1.1</td><td></td><td>%/°</td></tr>
<tr><td>Magnetic release point</td><td>H_{REL}</td><td>200</td><td></td><td></td><td>mT</td></tr>
<tr><td>Hysteresis</td><td></td><td>1</td><td></td><td>50</td><td>mT</td></tr>
<tr><td rowspan="4">Quiescent current</td><td rowspan="4">I_{DDQ}</td><td></td><td>1</td><td>2</td><td rowspan="4">µA</td><td>V_{DD} = 0.9V</td></tr>
<tr><td></td><td>1.4</td><td>3</td><td>V_{DD} = 1.15V</td></tr>
<tr><td></td><td>2</td><td>4</td><td>V_{DD} = 1.5V</td></tr>
<tr><td></td><td>2.8</td><td>7</td><td>V_{DD} = 1.8V</td></tr>
<tr><td>Output drive current</td><td>I_{OL-ON}</td><td>100</td><td></td><td></td><td>µA</td><td></td></tr>
<tr><td>Output low voltage</td><td>V_{OL}</td><td></td><td>0.05</td><td>0.2</td><td>V</td><td>V_{DD} = 1.5V;
I_{OL-ON} = 100 µA</td></tr>
<tr><td>Output leakage current</td><td>I_{OL-OFF}</td><td></td><td>0.095</td><td>0.5</td><td>µA</td><td></td></tr>
<tr><td>Maximum switching frequency</td><td>f</td><td></td><td>3000</td><td></td><td>Hz</td><td></td></tr>
</table>

Notes:
- 1 millitesla (mT) = 10 gauss (G) = 10 oersted (Oe) in air
  ESD per Human Body Model (HBM), JESD22-A114

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Operation

Omni-directional Sensitivity

As the magnetic field intensity varies, the AHK001's digital output will turn on and off. Unlike single-axis switches like Hall effect or other sensors, the AHK991 sensor is sensitive to magnetic fields in any direction, so multiple sensors are not needed for orthogonal or unknown directions of applied fields. The magnetic operate and release points are virtually unaffected by the angle of magnetic field in the plane of the sensor, and increase slightly for magnetic fields out of the plane of the sensor. The diagrams below show three permanent magnet orientations that will activate the sensor:

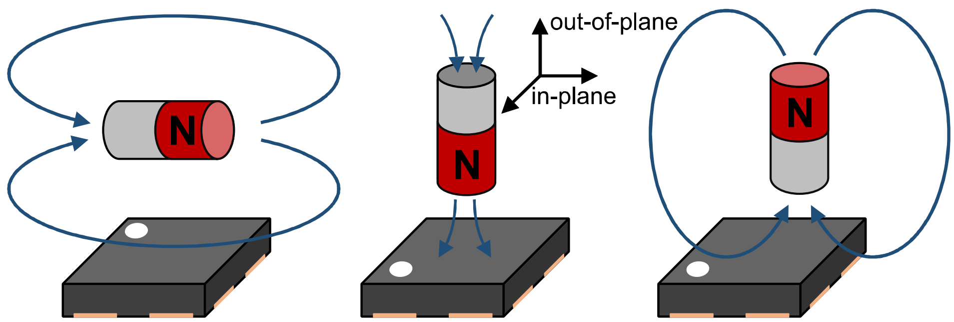


Figure 1. AHK991 sensor direction of magnetic sensitivity.

The omni-directional nature of the sensor also makes the sensitivity omnipolar. Either polarity applied fields activate the sensor.

External Pull-Up Resistor

The output is a logic low when the sensor is activated. The output is open-drain should have an external pull-up resistor. For microcontroller interfaces, the microcontroller's input pull-up resistors can be activated.

Typical Operation

Figure 2 shows an AHK991 sensor mounted to an available demonstration board:

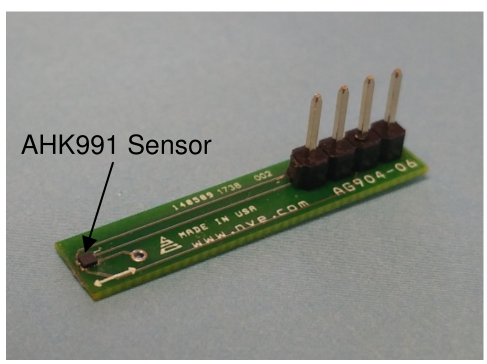


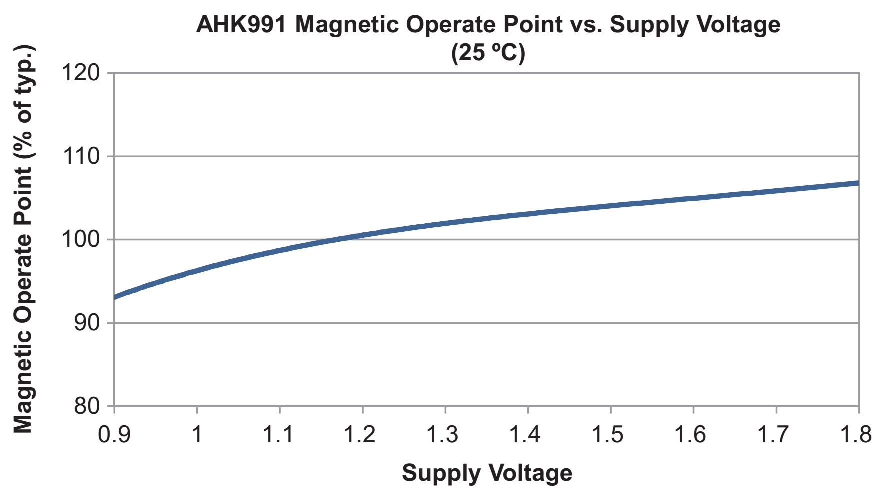
Figure 2. AHK991 on a circuit board.

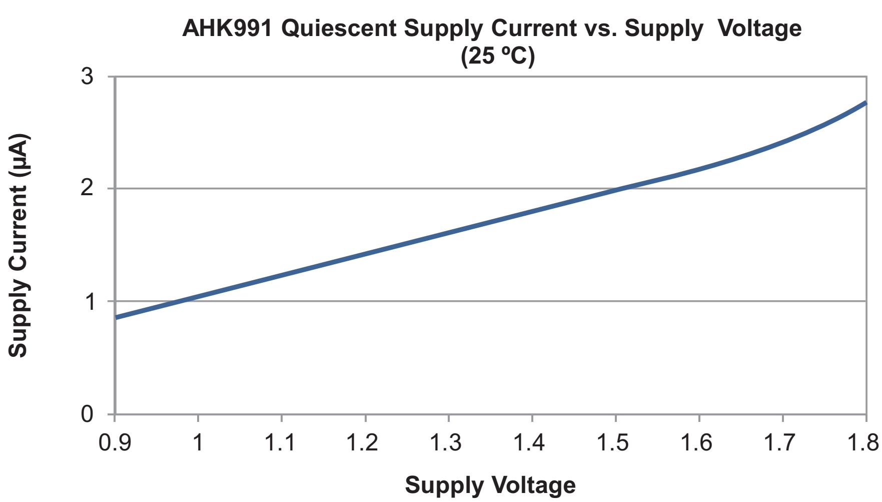
Typical switching distances from the face of the magnet to the center of the sensor for common rare-earth magnets are illustrated in the following table:

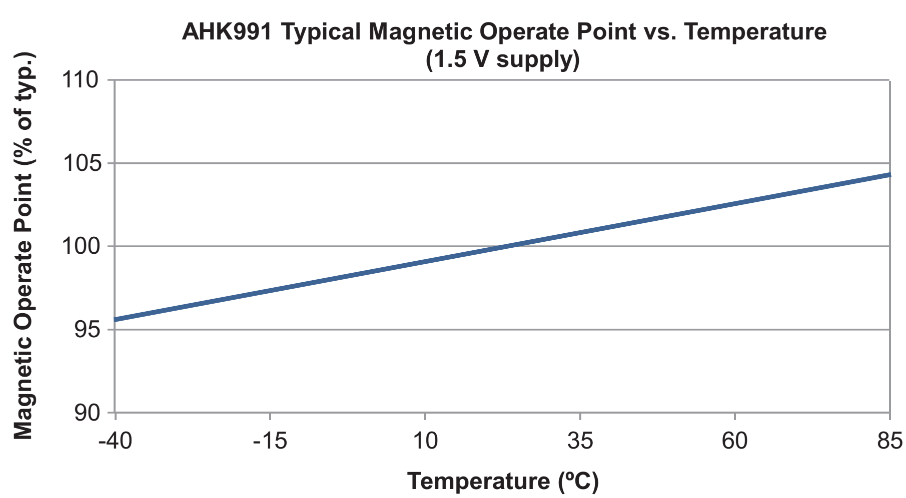
Magnet	Typical Operate Distance
6 mm dia. x 4 mm thick N45	1.1 mm
6 mm dia. x 25.4 mm long N45	1.6 mm
12.7 mm dia. x 12.7 mm thick N48	2.5 mm

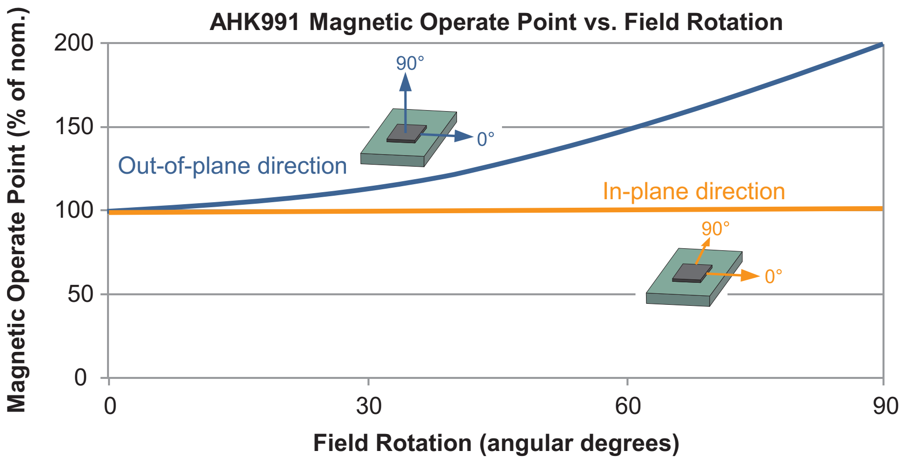
For more calculations, use our digital sensor switching versus distance Web application at: *www.nve.com/spec/calculators.php*.

Typical Performance








AHK991 Magnetic Operate Point vs. Field Rotation
Magnetic Operate Point (% of nom.)
200
150
100
50
0
0
30
60
90
Field Rotation (angular degrees)
Out-of-plane direction
In-plane direction
90°
0°
90°
0°

Part Numbering

This shows the AHK991 part number meaning:

AHK991 - 14E

Power Supply
AH = Single-cell
(0.9 – 1.8 V)

Technology
K = High-Field
Tunneling
Magnetoresistance

Duty Cycling
9 = Continuous duty

Typ. Magnetic Operate Point
91 = 350 mT

Package Type
01 = 0.625 x 0.625 mm bare die
14E = 1.1 x 1.1 x 0.35 mm ULLGA (RoHS)

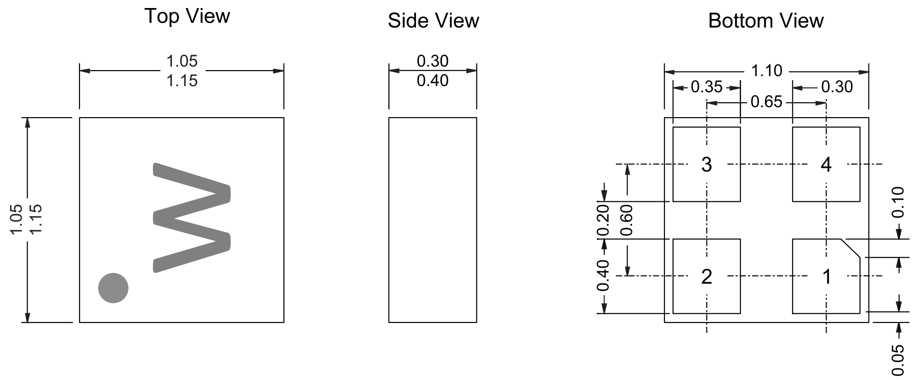
Bare Circuit Boards

NVE offers two bare circuit boards designed for easy connections to ULLGA sensors. Note that since these boards use very small sensors, they require reflow or hot-air soldering techniques. Images are actual size:

AG904-06: ULLGA General-Purpose PCB
A 30 x 6 mm (1.2 x 0.25 inch) PCB for demonstrating 1.1 x 1.1 mm ULLGA4 sensors (-14E sensor suffix).

AG039-06: ULLGA Digital Sensor Demonstration Bare Board
A 40 x 6 mm (1.57 x 0.25 inch) PCB for demonstrating AHK991 sensors (sensors sold separately). In addition to space for the sensor, the boards have locations for 0402-size pull-up resistors and bypass capacitors.

1.1 mm x 1.1 mm ULLGA Package (-14E suffix)



Dimensions in mm; ±0.05 mm unless otherwise noted.

RoHS COMPLIANT

Pad 1	No Connect
Pad 2	V_{DD}
Pad 3	Out
Pad 4	Ground

Soldering profiles per JEDEC J-STD-020C, MSL 1.

These products have been tested for electrostatic sensitivity to the limits stated in the specifications. However, NVE recommends that all integrated circuits be handled with appropriate care to avoid damage. Damage caused by inappropriate handling or storage could range from performance degradation to complete failure.

Revision History

SB-00-100A
December 9, 2019

Change
- Initial release.

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An ISO 9001 Certified Company

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